Lesson Plan Review
NSF GK-12 - Vibes and Waves in Action

Title of Lesson Plan: Ionizing Radiation & Biological Risk

Description of the overall plan for how the lesson was conducted

This was the first of a series of lessons on the risks and benefits of ionizing radiation. Today's classroom discussion focused on basic theory, units, detection methods and the biological effects of radioactive particles.

After a PowerPoint presentation, the class was given a demonstration to show how various household materials like smoke detectors, fiestaware plates and table salt contain low levels of radiation which are not a public health concern.

What transpired during the lesson?

The class started with a PowerPoint presentation and progressed into a demonstration. There was a lot of interest in the topic and most people were unaware of how much natural radiation was in the environment. The classroom was engaged, asking on topic questions that helped generate a good discussion and provided students with a better understanding.

Throughout the demonstration and for the following few weeks, I received various questions on the health concerns of ionizing radiation, what a reactor looks like and what materials really have radiation in them.

What worked during the lesson?

The demonstration was a hit and the students asked some really intelligent questions on the effects of radiation they encounter in their everyday lives.

What could have been improved to make a more effective lesson?

Honestly, there wasn't enough time to do everything. I think the presentation and demonstration would have been more effective if broken down into several lessons on the fundaments of the subject.

Blake Currier
GK-12 Lesson Plan #1

Period: **Class: LHS, Freshman Algebra**
Date(s):

SETTING THE STAGE	
Essential Question	What is a radioactive particle and how is it measured?
Content Objective(s) (Student-friendly)	We will learn about some of the basic physics principles involving radiation, analyze different radioactive sources that can be seen every day and understand why there are practical uses for radiation.
Connection to previous or future lessons	This is the first lesson in a series regarding radiation safety and life. It is important that students understand the basic fundamental concepts of how radiation relates to fundamental physics principles.
Critical Thinking Questions	What does ionizing radiation mean? What are some ways we use radiation in our everyday life?
Key Vocabulary	Ionizing Alpha Beta Gamma ALARA Absorbed Dose
Materials Needed/Safety	GM Detector Radiological Science Kit Journals Pens Calculator
ACTIVE INSTRUCTION	
• Launch (Engage)	Radiation is used to help generate power, produce functional internal medicine images and treat different forms of cancer. By understanding what radiation is we can better understand how it is used

• Investigation (Explore)	Using the GM detectors, students will be given a demonstration showing how smoke detectors use radioactive sources to detect fires. Students will be asked to interpret readings at varying distances from a smoke detector without the cover on. Using these counting results they will be asked to assess exposure risks to humans within a normal household area.
TIME FOR REFLECTION	
• Summarization (Explain & Extend)	
• Assessment (Evaluate)	One on one assessment while students are assessing exposure results
• Homework	None

Ionizing Radiation & Biological Risk Assessment

By

Blake Currier


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The red
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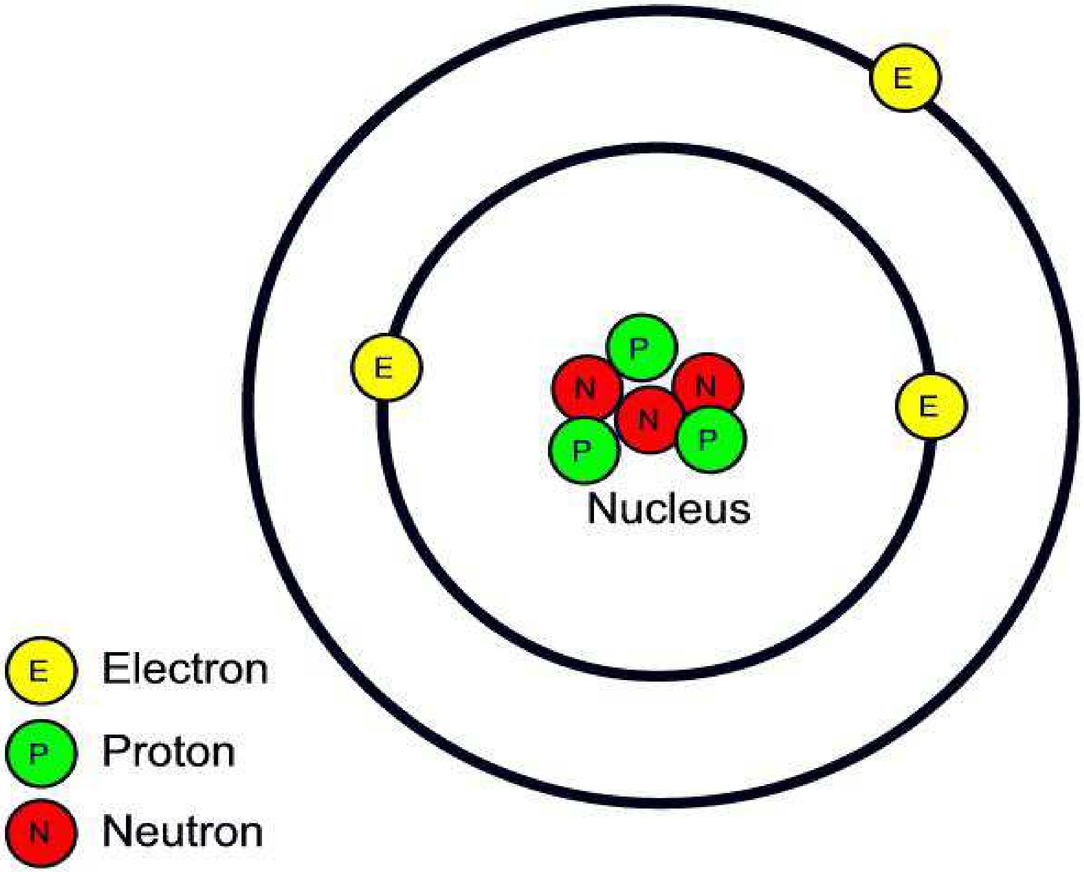
Presentation Outline

- Radiation theory
  - Atomic Structure
  - Types of Radiation
- Units of Measurement
  - Absorbed Dose & Dose Equivalence
- Detection & Shield Methods
- Biological Effects Due to Radiation
  - Exposure risks to the US population
  - Risk & Benefit Analysis
- Uses of Radiation
  - Medical Facilities
  - Industry
  - Households

Atomic Structure



Types of Ionizing Radiation

- Alpha Particles
  - Two Protons & Two Neutrons
- Beta Particles
  - Electrons
- Gamma & X-rays
  - Photons
- Neutrons
  - Part of the atomic nucleus

Alpha Particles

- Consists of two protons & two neutrons (a helium ion)
- Alpha particles are very large and the least penetrating form of ionizing radiation.
- Alpha particles can’t penetrate the dead skin layer
- Typically only internal exposure hazards

Beta Particles

- Made of electrons that originate in the nucleus
- Beta minus decay
  - Neutrons break apart to create a proton, electron and antineutrino.
- Beta plus decay
  - Protons break apart to create a neutron, positron and neutrino

X-Rays & Gamma Rays

- X-Rays and gamma radiation are both photons that travel at the speed of light
- Gamma rays originate from the <u>nucleus</u>
- X-Rays originate from the energy transition of orbital electrons
- Higher energy photons have shorter wave lengths.

Neutrons

- Part of an atoms nucleus
- Neutral charge
- Interacts readily in hydrogenous material

Ionizing Radiation Quantities & Units

- Absorbed Dose – Rad or Gray (Gy)
  - A rad is defined as a dose of 100 ergs of energy per gram of tissue (1 Gy = 1 J/Kg).
  - 1 Gray equals 100 rads
- Dose Equivalence – Rem or Sieverts (Sv)
  - Dose equivalence incorporates quality factors in order to assess the risk of lower specific hazards.
- Activity – Curie (Ci) or Becquerel (Bq)
  - The strength of a radioactive source
- Exposure – Roentgen (R)
  - The strength of a radioactive field in area.
  - A roentgen is the amount of energy required to produce 1.6E12 ion pairs.

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Radiation Quantities & Units Table

Dose to Tissue (Absorbed Dose)	Dose Equivalence	Activity	Exposure
Rad or Gy 1 Rad = 10 mGy 100 Rad = 1 Gy	Rem or Sv 1 Sv = 100 rem 1 mSv = 100 mrem	Curie or Bq 1Ci = 3.7E10Bq	R or C/kg 1R = 1 μC/kg

Radiation Detection

- One type of Radiation detectors
  - Geiger Mueller (GM)
    - operates by collecting charge the of an ion pair (with gas multiplication) ionizing all the detector gas

Other Forms of Detection

- Ion Chambers

- Scintillation Detectors

- Solid State Detectors

How to Keep Doses
As Low As Reasonably Achievable (ALARA)

- **TIME-** *Decrease* your time spent near a radiation source
- **DISTANCE-** *Increase* your distance from the radiation source
- **SHIELDING-** *Increase* shielding between yourself and the radiation source

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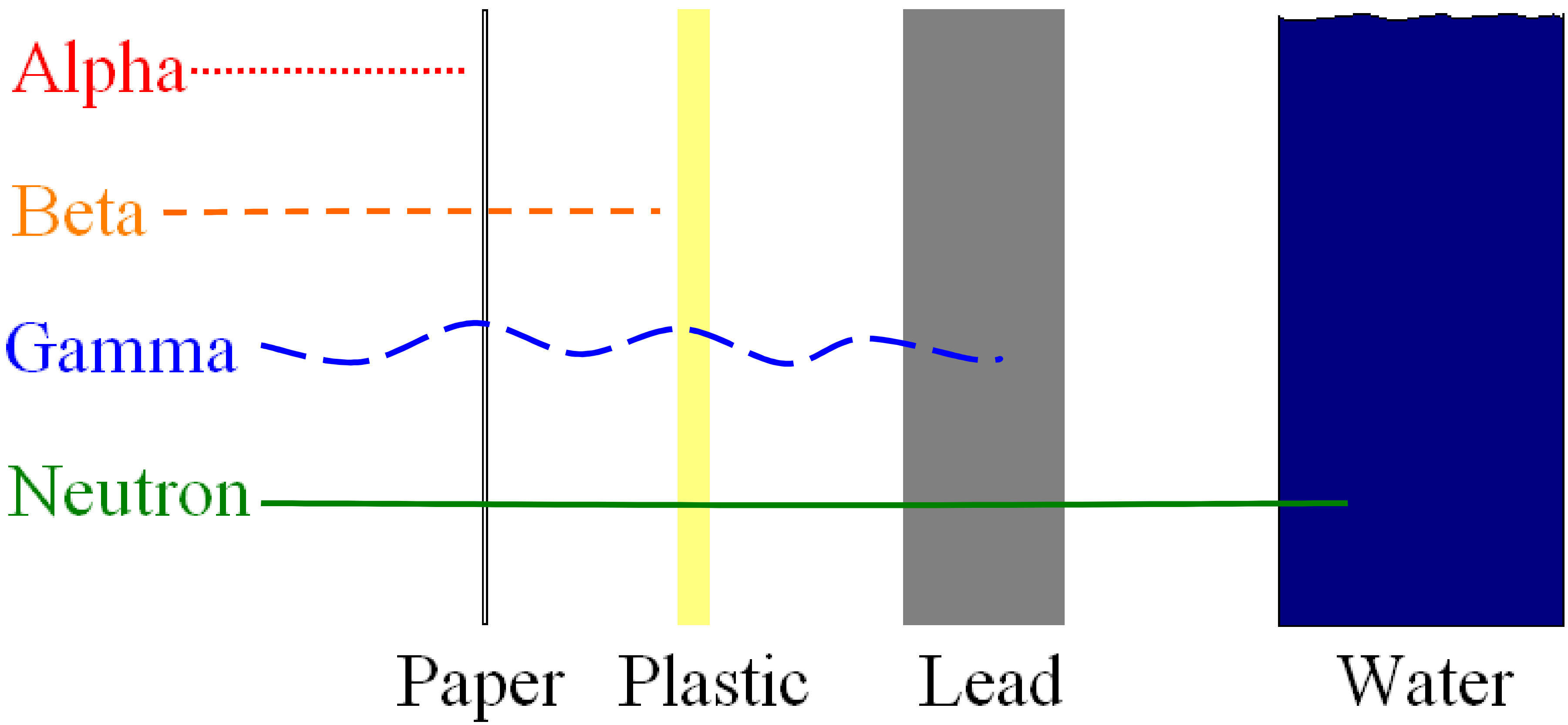
Shielding Methods



Personal Protection

Protective Clothing

Biological Effects Due to Radiation

- Where Dose Radiation Come From?
- What are the risk?
- How has exposure to radiation increased?

Where can we find Radiation Material?

- Radioactive material is all around us
  - Potassium 40 – Salt and Bananas
  - Americium 241 – Smoke Detectors
  - Uranium 235, Uranium 238, Thorium 232, Radium 225 & Radon 220 – All Typical isotopes found natural within the earth
  - Carbon 14, Hydrogen 3 & Beryllium – All Typical sources of cosmogenic radiation

Radiation Exposure per Activity

• Flight from NY to LA	2.5 mrem/Trip
• Full Mouth X-Ray	9 mrem/scan
• Chest X-Ray	10 mrem/scan
• CT Scan	800-1300 mrem/scan
• PET Scan & SPEC	1500 mrem/scan
• Radon Gas	200 mrem/yr
• Smoking	1300 mrem/yr

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Health Risk Relative to Radiation Exposure

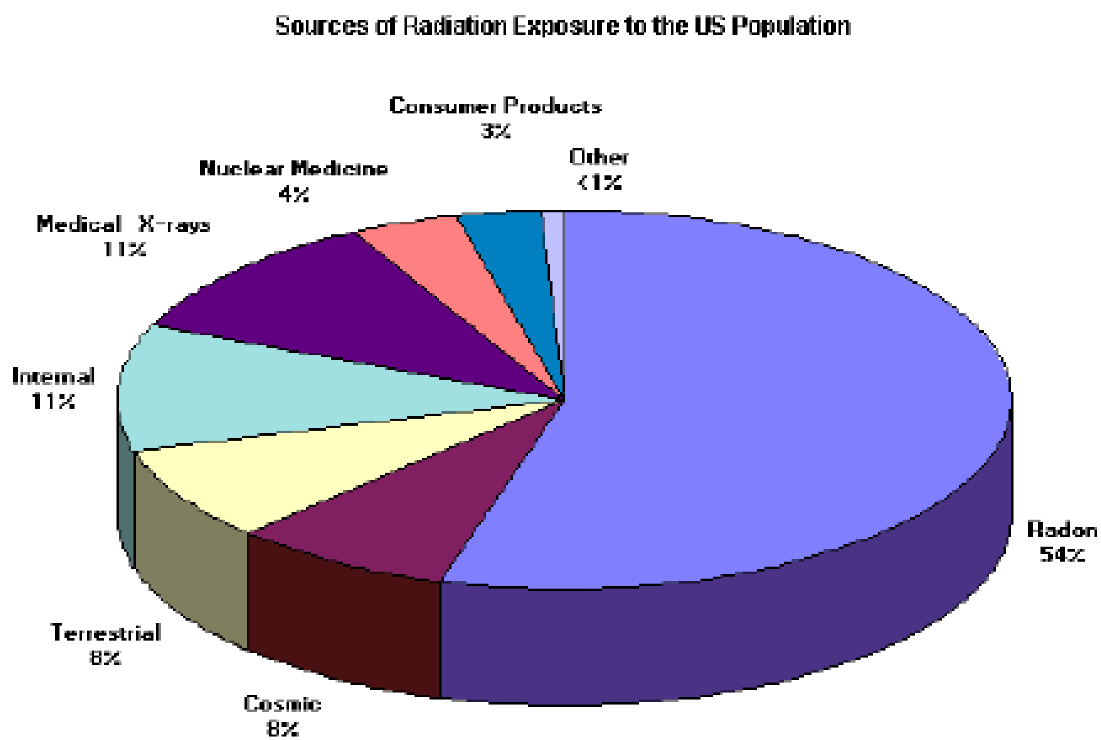
Health risk	Days of life lost
• Smoking 1 pack of cigarettes a day	2370
• 20% overweight	985
• Average US alcohol consumption	130
• Home Accidents	95
• Dose of 5000 mrem/hr	32
• Dose of 500 mrem/hr	3

Occupational Radiation Exposure (above background)

• Medical personnel	70 mrem/yr
• Grand Central Station Workers	120 mrem/yr
• Nuclear power plant	160 mrem/yr
• Airline flight crew	1000 mrem/yr

Sources of Radiation Exposure to the US Population (NCRP 93)

Source	Dose (mrem/year	Percent of total
Background	**300**	**82**
Internal (inhalation of radon and thoron)	200	55
External (cosmic)	27	8
Internal (ingestion)	39	11
External (terrestrial)	28	8
Medical	**60**	**15**
Computed tomography	---	---
Nuclear medicine	14	4
Fluoroscopy (Interventional)	---	---
X-rays	39	11
Consumer	**10**	**3**
Occupational	**0.9**	**<0.3**
Nuclear fuel cycle	**<1**	**<0.03**
TOTAL (3.6mSv)	**360**	

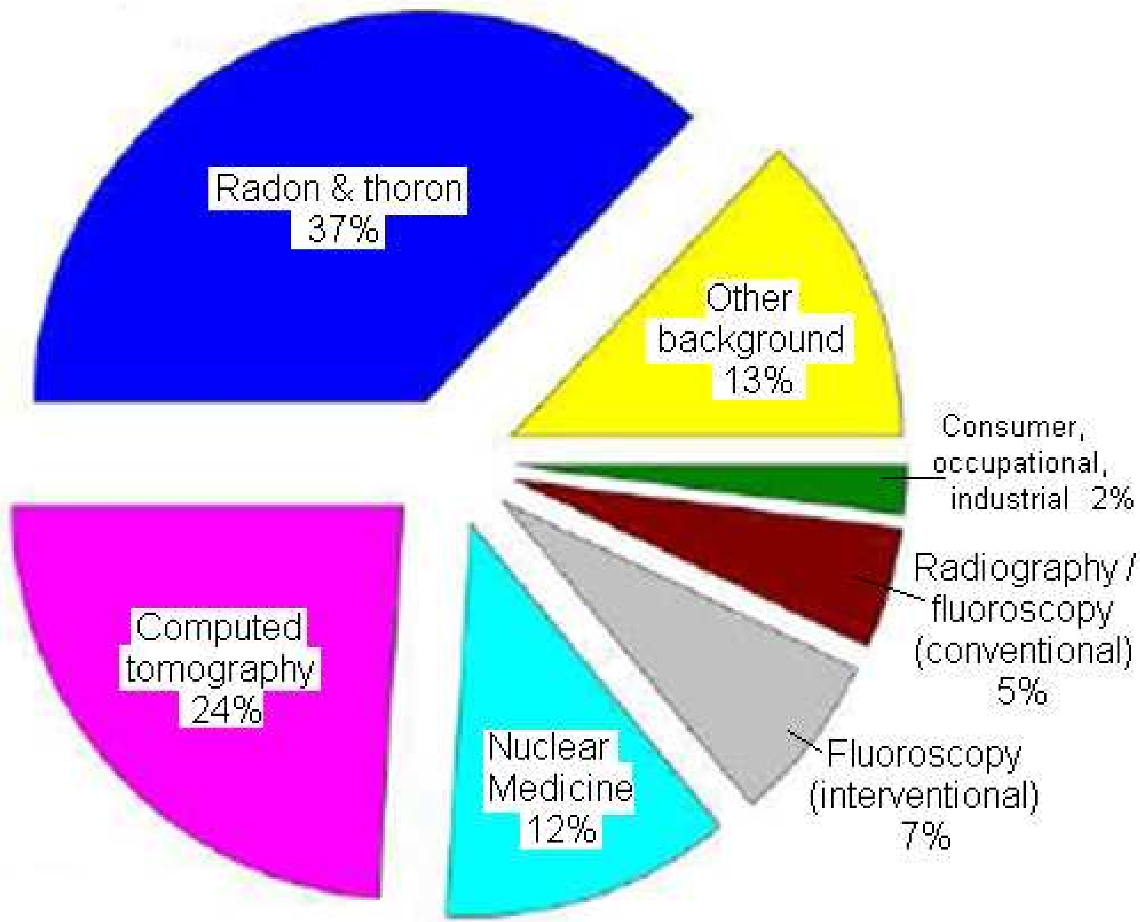


Sources of radiation exposure to US population. Adapted from NCRP 93

Early 1980's

Sources of Radiation Exposure to the US Population (NCRP 160)

Source	Dose (mrem/year	Percent of total
Background	**311**	**50**
Internal (inhalation of radon and thoron)	228	37
External (cosmic)	33	5
Internal (ingestion)	29	5
External (terrestrial)	21	3
Medical	**300**	**48**
Computed tomography	147	24
Nuclear medicine	77	12
Fluoroscopy (Interventional)	43	7
Fluoroscopy and radiography (Conventional)	33	5
Consumer	**13**	**2**
Occupational	**0.5**	**0.08**
Industrial, security, medical (education and research)	**0.3**	**0.05**
TOTAL (6.2mSv)	**620**	



2006

Average Annual Effective Dose Equivalent				
Source	NCRP 95		NCRP 160[2]	
	(μSv)	(mrem)	(μSv)	(mrem)
Inhaled (Radon and Decay Products)	2000	200	2290	229
Other Internally Deposited Radionuclides	390	39	310	31
Terrestrial Radiation	280	28	190	19
Cosmic Radiation	270	27	270	27
Rounded total from natural source	3000	300	3100	310
Rounded total from artificial Sources (Medical, industrial, etc)	600	60	3100	310
Total	3600	**360**	6200	**620**

Medical uses of Radiation

- X-rays
  - Observe broken bones
  - Contrast material for x-ray, Barium enema (not radioactive barium, angiogram for cardiology viewing)
  - Mammogram to view breast tissue looking for tumors
  - Computerized Tomography (CT) exam X-rays with computer processing to get 2-D slices of the body

Other Medical uses of Radiation

- Radiation oncology
  - Brachytherapy seed treatments of all kinds of cancer
  - Linear accelerator and Intensity modulated Radiation therapy (high energy x-rays and electron beams)
  - Gamma stereotactic surgery (gamma knife) for treatment of muscle issues (face tics), reduce tumors, blood vessel defects, epilepsy and Parkinson’s disease.

Industrial uses of radiation

- Power generation- use of fissionable material to heat water and spin a turbine generator that will produce power
- Industrial radiography- Iridium 192 to take images of welds, pipes, etc.
- Well logging- gamma or neutron source sent in a well to determine viability for certain valuable mineral mining

Industrial uses of radiation

- X-rays for security (airports)
- Food irradiation -kill bacteria that cause food to rot quicker
- Sterilization- hospital equipment, mail potentially containing biological compounds
- Static eliminating devices (po-210 alpha) to ionize the air

Household Uses of Radioactive Material

- Smoke detector
- Thorium lantern
- Old radium dial watches
- Fiesta ware dinnerware
- Old Glassware


X-RAY FLUOROSCOPE